Quantum in Finance Virtual Event
Q&A

Q: What is the timeline of technology for real impact? How impactful can a noisy quantum computer be?

A: The NISQ era is expected to last for this decade. We hope around 2030 to have fault tolerant machines that will open up many powerful use cases. But there is a growing consensus that we will achieve quantum advantage in at least one use case in the next 5 years thanks to the double exponential that was presented in the conference (qubits are doubling every year or so, and the Hilbert space of those machines is 2^#qubits) and improvements in algorithms (e.g. dataloader, variational techniques...). Quantum advantage will be use case and hardware dependent during the NISQ era.

Q: What are the top use cases of quantum information sciences in banking?

A: Please refer to this report from BCG: https://www.bcg.com/publications/2020/how-financial-institutions-can-utilize-quantum-computing. Additionally, some of the earlier speakers addressed this question and you can review them through the provided recordings. This is also a another place to start (more technical): https://arxiv.org/abs/1807.03890

Q: What should be the roadmap to educational institutions to prepare the future students in the area of quantum computing?

A: For starters, it may be worth watching the QIS Workforce Development Panel, where this topic was discussed to some degree. Additionally, initiatives like the National Q-12 Education Partnership and the Q2Work Program (https://q12education.org/) are working to define this sort of roadmap. There are also numerous resources online that outline key concepts for creating future QIS leaders (https://qis-learners.research.illinois.edu/) and (http://www.mit.edu/~aram/advice/quantum.html) and (https://u.osu.edu/quantinfo/research/researchprep/)

Q: What are the constraints, if any, on building the required hardware to properly advance quantum computing?

A: On the hardware side, there are still many hurdles to be overcome to scale qubits in quantity, quality and connectivity. They depend on the underlying technology (e.g. superconducting, trapped ion, photonic, annealing…). For example, in superconducting qubits, circuitry is a known bottleneck. In the current architecture, 3 cables are required per qubit which was possible at 50-100 qubits, but needs a rethink for more. Startups such as Delft Circuits are developing compacter circuitry that is probably taken into account in the hardware roadmaps of hardware manufacturers.

Q: Can quantum annealing provide an opportunity to achieve quantum advantage?

A: Annealing hardware has been controversial in terms of its actual ability to achieve quantum advantage. Annealing algorithms can be run on gate-based quantum hardware, however, and are quite promising for solving problems in the near term. One documented issue to obtain advantage is the connectivity to qubit ratio (6/2000 before, now 16/5000) as demonstrated by UK QT programme - please see this talk for more : https://slideslive.com/38918804/use-case-quantum-algorithms-for-telecoms-network-optimization-and-distribution-logistics

Q: For the improvements in the Variational Quantum Eigensolver for molecules described by Professor Chong, are these real computations in real hardware or is an algorithm-design type of development?

A: The deuteron computation is on real hardware, but it is a very small problem. Better gate fidelities are needed before larger problems can be run. In 3-5 years, it may be possible to solve for a system that would be challenging for a supercomputer.

Q: What would be the impact of qutrits to quantum algorithms more generally?

A: Current qutrit techniques are transparent to algorithms (the software optimizes automatically), but it's possible to get even more out of qutrits if algorithms were coded in a more general way, rather than often having qubits and qubit gates already baked in to the implementation. This strategy is also true for Prof. Chong's recent work on multi-qubit gates.

Q: To Professor Chong, what kind of partnership are you looking to start with potential industry partners and which kind of applications would you like to explore?

A: EPiQC and Super.tech are interested in applying our software tools to optimize for some targeted pilot applications. Portfolio optimization, for example, is an application we are interested in. We would like partners to help us identify other use cases that are a good match for near-term quantum algorithms and machines. Please note that the key differentiating feature of the software described by Prof. Chong is its high efficiency due to close integration with the physics of machines.

Q: There will likely be a need for a series of facilities, high tech labs and high speed fiber optic networks constructed in different places around the state/region to accommodate this research and to house the quantum infrastructure. Can you talk about these facilities, where they will need to be located, constructed, the states and universities respective roles and related procurement processes. Is their a governing board, public private partnership, or committee to address these issues?

A: At a national level, the Quantum Economic Development Consortium (QED-C; https://quantumconsortium.org/) is likely the most notable public-private partnership focused on framing the needs of a robust quantum ecosystem. Within Illinois, the Chicago Quantum Exchange (CQE;) is another organization that we would expect to help address these issues and also house the research organizations, e.g., Argonne, Fermi, UChicago, UIUC, etc., that would house many of these facilities, at least regionally.

Q: What is the QC-Ware solution to QRAM problem ? Is there a paper addressing this approach?

A: This presentation from QC-Ware provides a bit more information: https://www.minnequantum.org/files/vic_mpls_qc_meetup_20200212.pdf (slide 93 and onwards).

Q: Are ethics in algorithms being implemented/considered?

A: In classical AI, BCG has researched what is called "Responsible AI" : https://www.bcg.com/publications/2020/six-steps-for-socially-responsible-artificial-intelligence The same bias issues and mitigations approaches are expected to be valid with QML when it will become pratical. Q2B 2020 will feature a panel discussion on this aspect in December.

Q: We heard about Amazon Scholars and other examples of vendors supporting scientific research. What are some good approaches for finance companies to interface with quantum research labs in academia and at the national labs. What types of public private partnerships will avoid problems with issues such as those that arise around intellectual property?

A: P33's Quantum Cohort (https://quantump33.com/) program offers a low friction way for "quantum curious" organizations to interface with quantum research labs in Illinois. However, at some point, partnerships between public and private will likely require a contract and the requirements for each academic or national lab will be defined by that institution's policies, including those relating to intellectual property. By starting and growing these relationships early, it may be possible to lower the barriers to entry into such partnerships.

Q: There was a reference to the US government's report on the state of quantum, could you share a link to this document?

A: Please see this report:
https://www.quantum.gov/wpcontent/uploads/2020/10/QuantumFrontiers.pdf

Q: How and when would you expect a reduction in the barrier to entry into the quantum field from graduates and postdoctoral researchers toward undergraduates given the advent of courses like IBM Qiskit summer school and other curricula/programming in this space?

A: While this is a difficult question to answer, as the panelist in QIS Workforce Development panel discussed, such curricula and programming are being considered now. These efforts need to be development thoughtfully and it takes a significant amount of time to implement new degree programs, so it likely makes sense to rely on programs like those of IBM Qiskit to supplement your quantum education until a graduate program or other training program arises that meets your needs.

Q: For companies developing quantum technologies, how might they begin to partner with finance institutions or even computer manufacturers to do benchmarking or for further technology development?

A: Fundamentally, and somewhat unsurprisingly, all startups must network effectively in order to connect with individuals within relevant partner organizations. The goal isn't to connect with just anyone within the organization, but rather to engage the decision maker or a person near to the decision maker within the business unit for which your technology is most useful. Assuming that you are able to make a potential useful connection, the next critical step is ensuring your value proposition is abundantly clear and directly addresses a business need for the organization.